ARIZONA TRANSPORTATION RESEARCH CENTER

RESEARCH NOTES:

Project 595

December 2006

Real-Time Adaptive Ramp Metering: Phase I – MILOS Proof of Concept

(Multi-Objective, Integrated, Large-Scale, Optimized System)

Congested urban freeways result in lost time, driver frustration, higher public and business costs, wasted fuel, decreased productivity, increased accidents, and severe degradation of regional air quality. One successful approach to alleviate some of these congestion effects is to spread the vehicle loading on the freeways through ramp metering, which controls the arrival rates of new vehicles on to the freeway.

A research team from the ATLAS (*Advanced Transportation and Logistics: Algorithms and Systems*) Research Center of The University of Arizona (UA), with support from the Arizona Transportation Research Center (ATRC) of the Arizona Department of Transportation (ADOT), has developed an Adaptive Ramp Metering System, referred to as MILOS (*Multi-Objective, Integrated, Large-Scale, Optimized System*).

MILOS considers the demand on a freeway segment from upstream mainline flow and from on-ramps in the segment, and sets rates adaptively to minimize total delays of the vehicles using this corridor. Earlier simulation based studies have shown that MILOS has the potential to be highly effective in decreasing delays and making freeways flow smoother. In addition, MILOS recovers quickly and smoothly from oversaturated conditions.

ADOT's ATRC will be implementing and testing MILOS on a segment of Interstate 10 in south Phoenix and Tempe, through a two-phase approach. This report documents the work performed in 2005-06 on the *SPR 595 MILOS Adaptive Ramp Metering Implementation – Phase I* research project by UA for ADOT.

The scope of this Phase I project was to demonstrate the integration of the existing ADOT Freeway Management Systems (FMS), the new ADOT traffic management system (the *i2* Traffic Management System developed by Siemens ITS), and new NTCIP (National Transportation Communications for ITS Protocol)-based ramp metering firmware.

If this integration can be achieved through this research, then, in the future, any ramp rate, especially the optimum ramp rate as determined by MILOS, can be downloaded to the ramp meters using the upgraded software, hardware, and communication infrastructure available to the ADOT FMS and the *i2* Traffic Management System.

MILOS will control the ramp meters at:

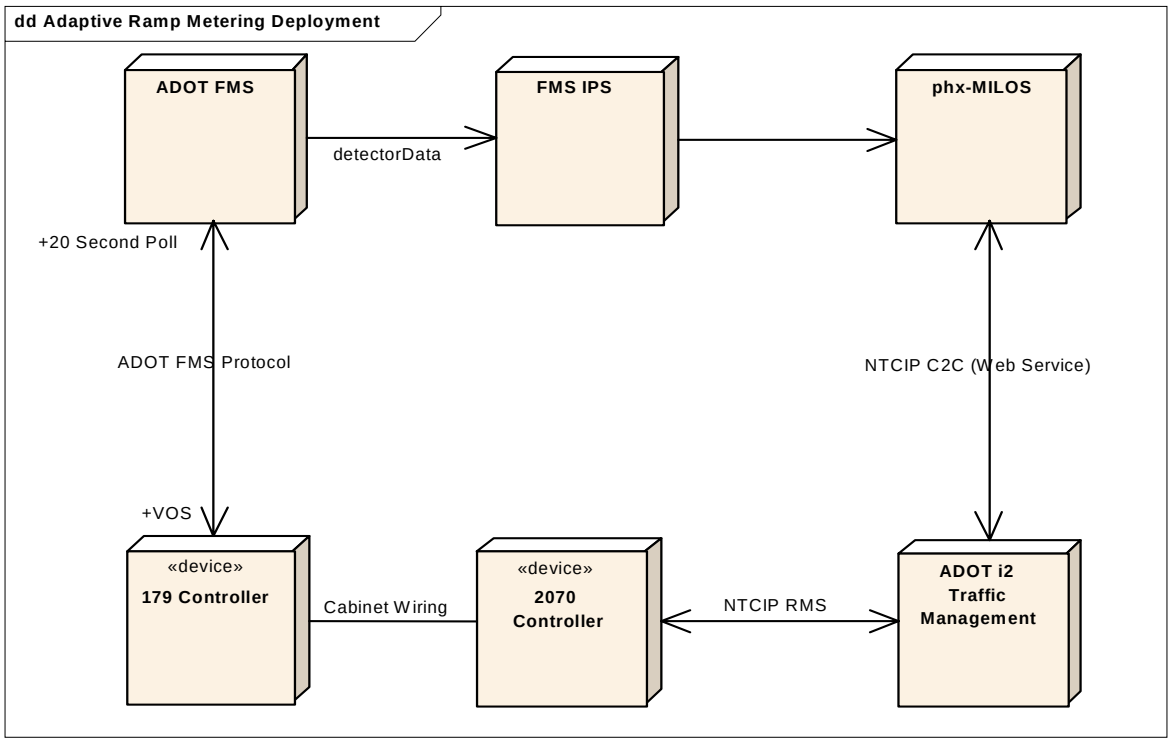
- Ray Road & I-10 Westbound
- Warner Road & I-10 Westbound
- Elliot Road & I-10 Westbound
- Broadway Road & I-10 Eastbound
- Baseline Road & I-10 Eastbound
- Elliot Road & I-10 Eastbound
- Warner Road & I-10 Eastbound

The scope of the upcoming Phase II effort is to demonstrate and evaluate MILOS' capability to implement adaptive ramp metering rates to positively affect traffic flow performance on the selected freeway study corridor, consisting of seven metered traffic-interchange ramp locations along Interstate 10 in southeast Phoenix and Tempe (as indicated by the oval in the regional map above).

The project required the design, integration and implementation of the interfaces among field ramp-metering controllers, the MILOS software, and ADOT's FMS and *i2* Traffic Management System.

The MILOS architecture, algorithms and software were developed in as series of earlier research projects, some partially supported by ADOT / ATRC.

The following figure illustrates the primary components of the integrated system. MILOS (residing in the server referred to as *phx-MILOS*) receives mainline and ramp detector data from the ADOT Freeway Management System using a binary data stream. The *i2* Traffic Management System and the FMS communicate to the 179 and 2070 controllers using separate channels on the ADOT fiber communications system.



The integrated system and proof-of-concept demonstration was conducted at the ADOT Traffic Operations Center on March 31, 2006, using an *i2* client Graphical User Interface (GUI) to view the status of each ramp controller.

In addition, two windows were used to view the MILOS software and the *i2* Center-to-Center (C2C) component. One of these display windows showed that MILOS was running and that data was received every 20 seconds from the FMS / IPS (Incident Processing System) server. The *i2* C2C window showed that the desired rates were being sent as the commanded rates to the *i2* interface from MILOS. Finally, the desired rates appeared as the "Active Metering Rates" when implemented on the ramp controller.

The demonstration was considered a success by the ATLAS researchers and the members of the research project's Technical Advisory Committee (TAC).

The four major outcomes of this research project were:

1. The re-engineering of the MILOS software to communicate with other systems using interfaces for getting streaming detector data (input) from the FMS and sending commands (output) to ramp-metering controllers (to set metering rates).
2. The software interfaces between the different components in the integrated system to operate MILOS: the FMS detector system, MILOS algorithms, the NTCIP compliant ADOT *i2* Traffic Management System, and the ramp meter controllers.
3. Successful demonstration of the integrated system.
4. The identification of issues related to the performance of MILOS due to the partial availability of detector data – which will be addressed in Phase II effort.

The ATLAS Research Center, of the College of Engineering at the University of Arizona, is the lead entity that conducted this Phase I research program.

Key partners who contributed towards the writing, software development and/or data gathering include graduate research assistants in the ATLAS Center; Siemens ITS, who coordinated the installation and upgrade of the field ramp meter controllers to new 2070 controllers running NTCIP-compliant firmware; OZ Engineering, who provided the FMS/IPS interface; and ADOT staff from the Information Technology / Transportation Technology Group.

Stakeholders from ADOT and local agencies in the Phoenix area served on or advised the research Technical Advisory Committee; their continual active participation, technical input and support resulted in the project's success.

The following ADOT traffic engineering and technology sections, and partner agencies, were represented on the TAC:

- Transportion Technology Group, ADOT
- TTG-Traffic Operations Center, ADOT
- Phoenix Maintenance District, ADOT
- Traffic Engineering Group, ADOT
- Transportation Division, City of Tempe
- Traffic Operations and Signals, City of Phoenix
- Traffic Signal Systems, City of Chandler
- Maricopa Association of Governements (MAG)
- Transportation Planning, Maricopa County Department of Transportation
- Federal Highway Administration
- Arizona Transportation Research Center, ADOT

The full report: *Real-Time Adaptive Ramp Metering: Phase I – MILOS Proof of Concept*, by Drs. Larry Head and Pitu Mirchandani, University of Arizona (Arizona Department of Transportation, report number FHWA-AZ-06-595, December 2006) is available on the Internet. Educational and governmental agencies may order print copies from the Arizona Transportation Research Center, 206 South 17th Avenue, MD 075R, Phoenix, AZ 85007; FAX 602-712-3400. Businesses may order copies from ADOT's Engineering Records Section.